

Claims

- [c1] 1. A method of making an embedded attenuated phase shift mask (EAPSM) comprising:
- providing a phase shift mask substrate having a layer of phase shifting material and a layer of an opaque material;
- depositing a first resist layer on the substrate;
- exposing and developing the first resist layer and etching the substrate to create first level phase shifting image segments on the substrate corresponding to areas of critical structures to be exposed with the EAPSM;
- depositing a second resist layer on the substrate;
- providing a single frame exposure mask corresponding to non-critical areas outside the critical structure areas;
- using the single frame exposure mask, exposing the second resist layer;
- developing the second resist layer; and
- etching the substrate to remove the opaque material from the critical structure areas.
- [c2] 2. The method of claim 1 wherein exposing the first re-

sist layer is by use of a direct write electron beam or laser energy source, and wherein exposing the second resist layer is by an energy source other than the energy source used to expose the first resist layer.

- [c3] 3. The method of claim 1 wherein exposing the second resist layer is by simultaneous projection exposure.
- [c4] 4. The method of claim 1 further including identifying and storing the single frame exposure mask for future use with the EAPSM.
- [c5] 5. The method of claim 4, wherein the EAPSM is re-worked, and further including using the single frame exposure mask to remanufacture the EAPSM.
- [c6] 6. The method of claim 4, wherein the EAPSM is damaged, and further including using the single frame exposure mask to repair the EAPSM.
- [c7] 7. The method of claim 4, wherein the EAPSM is redesigned, and further including using the single frame exposure mask to remanufacture the EAPSM.
- [c8] 8. The method of claim 4 further including identifying and storing the single frame exposure mask for future use with other EAPSMs in the same mask set as the EA-SPM.

- [c9] 9. The method of claim 3 further including identifying and storing the single frame exposure mask for future use with other EAPSMs having the same chip or field size as the EASPM.
- [c10] 10. The method of claim 1 wherein the single frame exposure mask uses a 1:1 reduction ratio to expose the second resist layer.
- [c11] 11. The method of claim 1 wherein the single frame exposure mask uses a reduction ratio other than 1:1 to expose the second resist layer.
- [c12] 12. A method of making an embedded attenuated phase shift mask (EAPSM) comprising:
 - providing a phase shift mask substrate having a layer of phase shifting material and a layer of an opaque material;
 - depositing a first resist layer on the substrate;
 - exposing the first resist layer with a direct write electron beam or laser energy source;
 - developing the first resist layer and etching the substrate to create first level phase shifting image segments on the substrate corresponding to areas of critical structures to be exposed with the EAPSM;
 - depositing a second resist layer on the substrate;

providing a single frame exposure mask corresponding to non-critical areas outside the critical structure areas;

using the single frame exposure mask, exposing the second resist layer by simultaneous projection exposure;

developing the second resist layer; and

etching the substrate to remove the opaque material from the critical structure areas.

- [c13] 13. The method of claim 12 further including identifying and storing the single frame exposure mask for future use with the EAPSM.
- [c14] 14. The method of claim 13, wherein the EAPSM is re-worked, is damaged or is redesigned, and further including using the single frame exposure mask to repair or remanufacture the EAPSM.
- [c15] 15. The method of claim 13 further including identifying and storing the single frame exposure mask for future use with other EAPSMs in the same mask set as the EA-SPM, or with other EAPSMs having the same chip or field size as the EASPM.
- [c16] 16. The method of claim 12 wherein the single frame exposure mask uses a 1:1 reduction ratio to expose the

second resist layer.

- [c17] 17. The method of claim 12 wherein the single frame exposure mask uses a reduction ratio other than 1:1 to expose the second resist layer.
- [c18] 18. A method of making an embedded attenuated phase shift mask (EAPSM) comprising:
 - providing a phase shift mask substrate having a layer of phase shifting material and a layer of an opaque material;
 - depositing a first resist layer on the substrate;
 - exposing the first resist layer with a direct write electron beam or laser energy source;
 - developing the first resist layer and etching the substrate to create first level phase shifting image segments on the substrate corresponding to areas of critical structures to be exposed with the EAPSM;
 - depositing a second resist layer on the substrate;
 - providing a single frame exposure mask corresponding to non-critical areas outside the critical structure areas;
 - using the single frame exposure mask, exposing the second resist layer by an energy source other than the energy source used to expose the first resist layer;
 - developing the second resist layer;

etching the substrate to remove the opaque material from the critical structure areas; and identifying and storing the single frame exposure mask for future use with the EAPSM in the same mask set as the EASPM, or with other EAPSMs having the same chip or field size as the EASPM.

- [c19] 19. The method of claim 18, wherein the EAPSM is re-worked, is damaged or is redesigned, and further including using the single frame exposure mask to repair or remanufacture the EAPSM.
- [c20] 20. The method of claim 18 wherein exposing the second resist layer is by simultaneous projection exposure.